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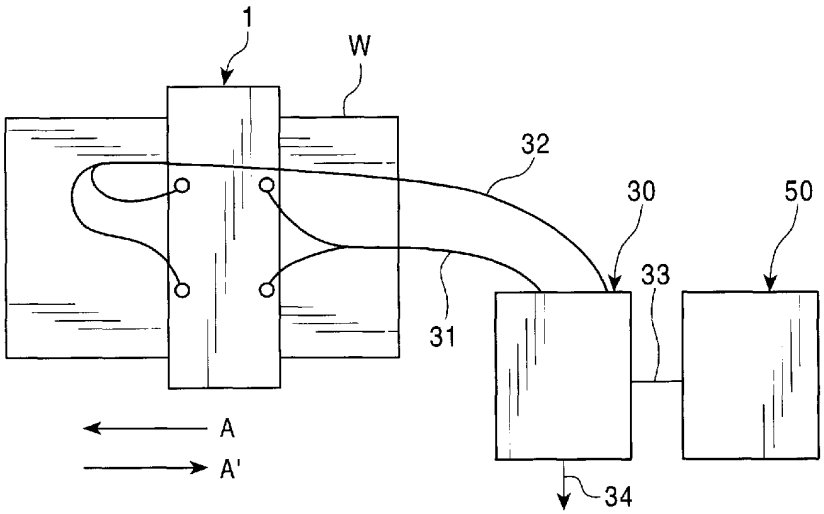
(54) Wet treatment apparatus

(57) A wet treatment apparatus includes a nozzle (1) having an approximately rectangular introduction opening surface (8a) which is open toward a substrate (W) to be treated and an approximately rectangular recovery opening surface (9a) which is open toward the substrate, these opening surfaces being flush with each other and disposed with the long side directions thereof in parallel with each other. A treatment liquid (L) is introduced between the introduction opening surface and the surface to be treated of the substrate and sucked and recovered from between the recovery opening surface and the surface to be treated of the substrate. At this time, the flow rate of the treatment liquid flowing from the introduction opening surface to the recovery opening surface through the surface to be treated of the substrate is controlled to 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface. With this arrangement, there can be provided a wet treatment apparatus capable of using a liquid saving type nozzle under optimum conditions.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a wet treatment apparatus for feeding a treatment liquid onto a workpiece to be treated at a wet treatment step such as a cleaning step, an etching step, and the like in a process for manufacturing, for example, a semiconductor device, a liquid crystal panel, and the like.

2. Description of the Related Art

[0002] In the field of electronic devices such as a semiconductor device, a liquid crystal display panel, and the like, a step for cleaning a semiconductor substrate and a glass substrate acting as a workpiece to be treated is indispensable in the manufacturing process of them. At the cleaning step, while the substrate is cleaned with ultrapure water, electrolyte, ozone water, hydrogen gas dissolved water, and the like to remove various substances therefrom in the manufacturing process, these cleaning liquids are fed onto the substrate from the nozzle of a cleaning apparatus. However, when a conventional ordinary cleaning nozzle is used, there is a problem that an amount of cleaning liquid to be used is increased. When it is intended to achieve a degree of cleanness of about 0.5 piece/cm^2 of particles as an amount remaining on a substrate of, for example, 500 mm square by cleaning the substrate with a cleaning liquid such as electrolyte or the like and then rinsing it with a rinsing liquid, the cleaning liquid and the rinsing liquid must be conventionally used in an amount of 25 to 30 L/min, respectively.

[0003] To cope with the above problem, there has been filed a wet treatment nozzle acting as a liquid saving type cleaning nozzle capable of greatly reducing an amount of cleaning liquid to be used as compared with conventional type cleaning nozzles. This wet treatment nozzle is used when a substance to be treated is subjected to wet treatment by feeding a treatment liquid onto the substrate. The wet treatment nozzle includes a treatment liquid introduction path formed at an end and having an introduction port for introducing a treatment liquid as well as includes a treatment liquid discharge path formed at an end and having a discharge port for discharging the treatment liquid after it is used. Further, an introduction opening and a discharge opening are formed to the other ends of the introduction path and the discharge path, respectively and open toward the substrate to be treated.

[0004] Then, a wet treatment nozzle device is provided by the above application and the like as a wet treatment nozzle device using the wet treatment nozzle. The wet treatment nozzle device has such a feature that it includes the wet treatment nozzle and a suck and discharge unit for sucking and discharging a treatment liquid, which has been in contact with the substrate to be treated through the introduction opening, after treatment through the discharge path by controlling the pressure difference between the pressure of the treatment liquid in contact with the substrate to be treated and the atmospheric pressure to prevent the treatment liquid from flowing to the outside of the discharge path.

[0005] Further, there is provided a wet treatment apparatus as a wet treatment apparatus that employs the above wet treatment nozzle. The wet treatment apparatus has such a feature that it includes the above wet treatment nozzle and a nozzle or substrate to be treated moving unit for treating the entire region of the surface to be treated of the substrate by relatively moving the wet treatment nozzle and the substrate along the surface to be treated of the substrate.

[0006] That is, according to the wet treatment apparatus of the above application and other wet treatment apparatuses, a liquid saving type nozzle can be realized which can remove a treatment liquid from on the substrate to be treated without causing the treatment liquid to come into contact with a portion other than the portion to which the treatment liquid is fed. Further, the provision of the moving unit for relatively moving the wet treatment nozzle and the substrate to be treated along the surface to be treated of the substrate permits the entire region to be treated of the substrate to be treated to be subjected to the treatment.

[0007] As described above, there have been developed wet treatment apparatuses capable of cleaning the entire surface of a substrate to be treated while greatly reducing a quantity of treatment liquid to be used. However, conditions, under which these wet treatment apparatuses are actually used, have not necessarily been examined sufficiently.

[0008] That is, while it is true that these wet treatment apparatuses have been arranged as liquid saving type wet treatment apparatuses, conditions under which they are actually used such as a flow rate of a treatment liquid for optimizing treatment, an optimum relative moving speed between a substrate to be treated and a wet treatment nozzle, and so on have been determined through try and error in the respective wet treatment apparatuses. Thus, not only a long time is taken to determine conditions under which the wet treatment apparatuses are used but also there is a possibility that the wet treatment apparatuses are not always used under optimum conditions.

SUMMARY OF THE INVENTION

[0009] An object of the present invention, which was made to solve the above problems, is to clarify appropriate conditions under which a liquid saving type wet treatment apparatus as described above is used and to provide a wet treatment apparatus capable of being used under optimum conditions to thereby realize effec-

tive and efficient wet treatment.

[0010] To solve the above problems, the inventors first examined a flow rate. An optimum flow rate is to be determined from the conditions that a treatment liquid uniformly flows from an introduction opening surface to a recovery opening surface and that wet treatment can be sufficiently executed with the flow rate. Then, the inventors found it necessary to examine an optimum flow rate per unit length in a direction perpendicular to the relatively moving direction of a wet treatment nozzle and a workpiece to be treated, and the value of the optimum flow rate was determined from an experiment.

[0011] That is, a wet treatment apparatus according to the present invention includes a nozzle having an approximately rectangular introduction opening surface which is open toward a workpiece to be treated and an approximately rectangular recovery opening surface which is open toward the workpiece to be treated, the introduction opening surface and the recovery opening surface being flush with each other and disposed with the long side directions thereof in parallel with each other;

a treatment liquid introduction unit having an introduction flow path for introducing a treatment liquid between the introduction opening surface and the surface to be treated of the workpiece to be treated; a treatment liquid recovery unit having a suction pump and a recovery flow path for sucking and recovering the treatment liquid from between the recovery opening surface and the surface to be treated of the workpiece to be treated; and a moving unit for the nozzle or the workpiece to be treated for relatively moving the nozzle and the workpiece to be treated along the surface to be treated of the workpiece to be treated as well as in the short side directions of the introduction opening surface and the recovery opening surface,

wherein the flow rate of the treatment liquid flowing from the introduction opening surface to the recovery opening surface through the surface to be treated of the workpiece to be treated is controlled to 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface.

[0012] That is, when the flow rate is less than 0.02 L/min, the treatment liquid cannot be sufficiently distributed to the surface to be treated of the workpiece to be treated as well as cannot be sufficiently replaced. In contrast, when the flow rate is greater than 0.3 L/min, an excessive treatment liquid flows to the outside of the surface to be treated as well as the stable flow of the treatment liquid on the surface to be treated is disturbed, whereby the treatment liquid is insufficiently replaced conversely.

[0013] According to the present invention, the treatment liquid is sufficiently distributed to the surface to be treated of the workpiece and sufficiently replaced as well as an excessive treatment liquid does not flow to the outside of the surface to be treated. Therefore, the wet treatment of the workpiece can be effectively executed.

[0014] Further, since the wet treatment can be executed with a small amount of treatment liquid, the size of piping, valves, an apparatus for manufacturing a treatment liquid such as pure water, etc., and so on can be reduced and the size of a wet treatment apparatus can be reduced in its entirety as well as a treatment cost can be decreased.

[0015] In the present invention, the flow rate can be controlled by regulating the sectional area of the introduction flow path and/or the recovery flow path. As a method of controlling the sectional area of each flow path, a method of disposing a regulator valve in a midway of piping for forming the flow path, a method of switching a flow path having a large sectional area and a flow path having a small sectional area, and the like can be appropriately employed.

[0016] Note that a method of using a fluid mass flow controller, and the like can be appropriately employed as another flow rate control method.

[0017] In the present invention, it is preferable that the lengths of the long sides of the introduction opening surface and the recovery opening surface be equal to or larger than the width, which is in the direction parallel to the long sides, of the workpiece to be treated. In this case, the entire surface to be treated of the workpiece can be treated by relatively moving the nozzle and the workpiece by the moving unit only once in one direction. Therefore, a time for treating the overall workpiece can be reduced.

[0018] In the present invention, it is preferable to set a relative moving speed due to the moving unit to 0.5 to 20 cm/sec. That is, when the moving speed is less than 0.5 cm/sec, not only a time for treating the overall surface to be treated is wastefully increased but also when bubbles are generated during treatment, they are deposited on the surface to be treated and the surface cannot be sufficiently treated partly.

[0019] In contrast, when the moving speed is greater than 20 cm/sec, a treatment liquid layer on the surface to be treated is broken by a shear force which is generated thereby, and the surface cannot be sufficiently treated partly during treatment. In addition, problems such as an increase in vibration of the treatment apparatus in its entirety, and the like are liable to be caused.

[0020] In the present invention, it is preferable that the distance between the respective opening surfaces and the surface to be treated of the workpiece be 0.5 to 6 mm. That is, when this distance is less than 0.5 mm, a resistance which is necessary for the treatment liquid to move is excessively increased, and it is difficult to secure the flow rate of 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface. Further, the contact of the nozzle with the workpiece is liable to be caused by the vibration of the treatment apparatus.

[0021] In contrast, when the distance is greater than 6 mm, it is not easy to keep the treatment liquid between the respective opening surfaces and the surface to be

treated, and air is liable to flow therebetween. Thus, it is difficult to stably flow the treatment liquid between the nozzle and the workpiece, and, as a result, there is caused a portion which is not treated.

[0022] In the present invention, it is preferable that the short sides of the respective opening surfaces have a length of 0.01 to 2 cm. That is, when the short sides of the respective opening surfaces are less than 0.01 cm, the resistance which is necessary for the treatment liquid to move is excessively increased, and it is difficult to secure the flow rate of 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface.

[0023] In contrast, when the short sides of the respective opening surfaces are greater than 2 cm, the treatment liquid cannot uniformly be fed from the introduction opening surface to the surface to be treated, and the treatment liquid on the surface to be treated cannot uniformly be recovered from the recovery opening surface, whereby the flow rate of the treatment liquid on the surface to be treated is made uneven.

[0024] In the present invention, an ultrasonic oscillation application unit may be interposed between the introduction opening surface and the recovery opening surface to apply ultrasonic oscillation to the treatment liquid on the workpiece. In this case, ultrasonic oscillation can be applied to the treatment liquid on the surface to be treated of the workpiece, whereby the efficiency of wet treatment such as cleaning and the like can be more improved.

[0025] In the present invention, an oxidation-reduction potential controller and a pH controller may be provided for the treatment liquid. In this case, since the composition and the concentration of the treatment liquid can be optimally maintained, a sufficient treatment efficiency can be secured even if a flow rate has a small value.

[0026] An embodiment of the present invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Fig. 1 is a plan view showing the overall arrangement of a wet treatment apparatus according to an embodiment of the present invention;

FIG. 2 is perspective view showing the outward appearance of a cleaning nozzle of a first embodiment of the present invention;

FIG. 3 is a lower plan view of the cleaning nozzle;

FIG. 4 is a sectional view taken along the line IV - IV of FIG. 3;

Fig. 5 is a view explaining a cleaning liquid introduction unit of the wet treatment apparatus according to the embodiment of the present invention;

Fig. 6 is a view explaining a cleaning liquid preparation unit of the wet treatment apparatus according to the embodiment of the present invention;

Fig. 7 is a view explaining an operation of the wet treatment apparatus according to the embodiment of the present invention;

Fig. 8 is a view explaining an operation of the wet treatment apparatus according to the embodiment of the present invention;

Fig. 9 is a view explaining an operation of the wet treatment apparatus according to the embodiment of the present invention;

Fig. 10 is a view explaining an operation of the wet treatment apparatus according to the embodiment of the present invention;

FIG. 11 is lower plan view showing a cleaning nozzle of a second embodiment of the present invention;

FIG. 12 is a sectional view taken along the line XII - XII of FIG. 11; and

FIG. 13 is a graph showing a result of experiment as to a flow rate and a cleaning effect.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[First embodiment]

[0027] A first embodiment of the present invention will be described below with reference to FIGS. 1 to 10.

[0028] Fig. 1 is a plan view showing the overall arrangement of a cleaning apparatus (wet treatment apparatus) of this embodiment. As shown in FIG. 1, the cleaning apparatus of this embodiment is composed of a cleaning nozzle 1, a moving unit (not shown) for moving the cleaning nozzle 1 and a substrate W to be treated (hereinafter, simply referred to as "substrate") acting as a workpiece to be treated in a moving direction A or A', a cleaning liquid introduction/recovery unit 30, and a cleaning liquid preparation unit 50.

[0029] In FIG. 1, reference numeral 31 denotes the introduction flow path of the cleaning liquid introduction/recovery unit 30 with one end thereof divided into two flow paths connected to the cleaning nozzle 1. Further, reference numeral 32 denotes the recovery flow path of the cleaning liquid introduction/recovery unit 30 with one end thereof also divided into two flow paths connected to the cleaning nozzle 1.

[0030] Reference numeral 33 denotes a feed flow path from the cleaning liquid preparation unit 50 to the cleaning liquid introduction/recovery unit 30. Further, reference numeral 34 denotes the discharge flow path of the cleaning liquid introduction/recovery unit 30.

[0031] As shown in FIGS. 2 to 4, in the cleaning nozzle 1 of this embodiment, a casing 2 is divided into three regions in its short side direction, and the regions at both ends are arranged a cleaning liquid introducing section 3 and a cleaning liquid recovery section 4, respectively, and the central region is arranged as an ultrasonic oscillator accommodating section 5.

[0032] Two cleaning liquid introduction pipes 6 and 6 are disposed on the upper surface of the cleaning liquid introducing section 3 by being spaced apart from each other in the long side direction of the nozzle 1. In the

same way, two cleaning liquid recovery pipes 7 and 7 are disposed on the upper surface of the cleaning liquid recovery section 4.

[0033] The upper ends of the respective cleaning liquid introduction pipes 6 are open and arranged as introduction ports 6a and 6a from which a cleaning liquid (treatment liquid) L is introduced, and the introduction flow path 31 of FIG. 1 is connected to the introduction ports 6a and 6a. In the same way, the upper ends of the respective cleaning liquid recovery pipes 7 are open and arranged as recovery ports 7a and 7a from which the cleaning liquid L is recovered to the outside after it is used, and the recovery flow path 32 of FIG. 1 is connected to the recovery ports 7a and 7a.

[0034] The interior of the cleaning liquid introducing section 3 is arranged as an introduction opening 8 communicating with the cleaning liquid introduction pipes 6 and 6, and the lower end thereof is arranged as an introduction opening surface 8a which is open toward the substrate W. The introduction opening surface 8a is formed in an approximate rectangle with its long side having a length L_N and its short side having a length d_1.

[0035] In the same way, the interior of the cleaning liquid recovery section 4 is arranged as a recovery opening 9, and the lower end thereof is arranged as a recovery opening surface 9a which is open toward the substrate W. The introduction opening surface 9a is formed in an approximate rectangle with its long side having a length L_N and its short side having a length d_2.

[0036] The introduction opening surface 8a and the recovery opening surface 9a are flush with each other as well as disposed with the long side directions thereof in parallel with each other. Then, the introduction opening surface 8a and the recovery opening surface 9a are formed such that the long sides thereof have the same length (L_N) and the short sides d_1 and d_2 thereof have approximately the same length. Further, the length L_N of these long sides is formed similar to or somewhat longer than the width L_W of the substrate W. The lengths of the lengths d_1 and d_2 of the short sides are set to 0.01 to 2 cm, respectively in this embodiment.

[0037] Note that the substrate W may be moved in the direction A from right to left of FIG. 3 in parallel with the respective short sides or in the direction A' opposite to the direction A.

[0038] Further, an ultrasonic oscillator 10 (ultrasonic oscillation application unit) is accommodated in the interior of the ultrasonic oscillator accommodating section 5 to execute ultrasonic cleaning by applying ultrasonic oscillation to the cleaning liquid L. A cable 11 for driving the ultrasonic oscillator 10 is disposed at the center of the ultrasonic oscillator accommodating section 5.

[0039] As shown in FIG. 4, a cleaning liquid feed member 12 (treatment liquid feed member) composed of a porous material is charged with the interior of the introduction opening 8 with the introduction opening surface 8a acting as the lower end surface thereof. Specifically used as the porous material are materials, for example, plastic such as fluorine resin, polyethylene, etc., metal such as SUS 316, etc., ceramics such as alumina, silicon oxide, etc., plastic subjected to hydrophilic treatment so as to provide its surface with a hydrophilic group, metal oxide such as TiO_2, and so on. Among these materials, hydrophilic materials such as the silicon oxide, the alumina, the plastic subjected the hydrophilic treatment, etc. are more preferable. Otherwise, it is not necessary to form the cleaning liquid feed member 12 of a hydrophilic material in its entirety but only at least the portion of the cleaning liquid feed member 12, which is in contact with the cleaning liquid L on the substrate W, may be formed of the hydrophilic material, or the surface of the cleaning liquid feed member 12 may be subjected to hydrophilic treatment. In any way, when the cleaning liquid L is fed into the introduction opening 8 through the cleaning liquid introduction pipes 6, the cleaning liquid L can be uniformly fed onto the substrate W through a multiplicity of through holes of the cleaning liquid feed member 12 because the cleaning liquid feed member 12 is formed of the porous material.

[0040] In contrast, a cleaning liquid recovery member (treatment liquid recovery member) 13 formed of a porous material also is charged with the interior of the recovery opening 9 with the recovery opening surface 9a acting as the lower end surface thereof. The porous material used in the cleaning liquid recovery member 13 may be similar to that used in the cleaning liquid feed member 12. However, the same type or a different type of a porous material may be used in the cleaning liquid supply member 12 and the cleaning liquid recovery member 13 in one nozzle. Since the cleaning liquid recovery member 13 is formed on the porous material, the cleaning liquid L remaining on the substrate W after it is used is sucked by a multiplicity of through holes of the cleaning liquid recovery member 13 and recovered to the outside of the nozzle 1 through the cleaning liquid recovery pipes 7.

[0041] The introduction opening surface 8a, the lower surface of the ultrasonic oscillator accommodating section 5 and the recovery opening surface 9a are formed so as to be flush with each other. The distance between these surfaces and the surface to be cleaned (surface to be treated) of the substrate W is set to 0.5 to 6 mm in this embodiment.

[0042] Next, the arrangement of the cleaning liquid introduction/recovery unit 30 of this embodiment will be described using FIG. 5. As shown in FIG. 5, a liquid feed pump 35, a liquid pressure controller 36 composed of a pressure reduction control valve, and the like, and a regulator valve (flow rate controller) 37 are sequentially disposed in the introduction flow path 31 from the feed flow path 33 side. A cleaning liquid introduction unit (treatment liquid introduction unit) is composed of the feed flow path 33, the liquid feed pump 35, the liquid pressure controller 36, the regulation valve 37, and the introduction flow path 31. Then, the operation of the liquid feed pump 35 causes the cleaning liquid L, which has been

prepared with the cleaning liquid preparation unit 50, to be introduced into the cleaning nozzle 1. Note that when the cleaning liquid L from the cleaning liquid preparation unit 50 has a sufficient pressure, the liquid feed pump 35 may be omitted.

[0043] Further, a suction pump 38 and a regulator valve (flow rate controller) 39 are sequentially disposed in the recovery flow path 32 from the discharge flow path 34 side. A cleaning liquid recovery unit (treatment liquid recovery unit) is composed of the discharge flow path 34, the suction pump 38, the regulator valve 39, and the recovery flow path 32. Then, the operation of the suction pump 38 causes the cleaning liquid L to be recovered and discharged from the cleaning nozzle 1.

[0044] The liquid pressure controller 36 controls the pressure difference between the pressure of the cleaning liquid L, which is kept between the cleaning nozzle 1 and the surface to be cleaned of the substrate W, and the atmospheric pressure by regulating the suction force of the suction pump 38 to thereby reliably recover the cleaning liquid L.

[0045] Further, the regulator valves 37 and 39 control the flow rate of the cleaning liquid L, which is introduced into the cleaning nozzle 1 and recovered, to 0.02 to 0.3 L/min per 1 cm of the long side of the introduction opening surface 8a by regulating the sectional areas of the introduction flow path 31 and the recovery flow path 32.

[0046] Next, the arrangement of the cleaning liquid preparation unit 50 of this embodiment will be described using FIG. 6. In FIG. 6, reference numeral 51 denotes a mixing bath connected to which are feed pipes composed of various types of materials depending upon types of the cleaning liquid L. Specifically, reference numeral 52 denotes an acid feed pipe, reference numeral 53 denotes an alkali feed pipe, reference numeral 54 denotes a pure water feed pipe, reference numeral 55 denotes an oxidizing gas feed pipe, and reference numeral 56 denotes a reducing gas feed pipe. Further, as shown in FIG. 6, the respective pipes 52 to 54 are provided with open/close valves 62 to 66 the opening and closing of which are controlled by a controller (not shown).

[0047] Further, the sensor 72 of a pH measuring instrument 71 and the sensor 74 of an oxidation-reduction potential measuring instrument 73 are dipped into the cleaning liquid L in the mixing bath 51 and the output values therefrom are supplied to the controller.

[0048] Then, the controller controls the opening/closing of the open/close valves 62 and 63 based on the output value from the pH measuring instrument 71 and controls the opening/closing of the open/close valves 65 and 66 based on the output value from the oxidation-reduction potential measuring instrument 73, respectively. As a result, the cleaning liquid L, to which a desired pH and a desired oxidation-reduction potential is applied, can be prepared in the mixing bath 51 (pH control unit and oxidation-reduction potential control unit).

[0049] The aforementioned feed flow path 33 is connected to the mixing bath outlet 81 of the mixing bath 51, and the thus prepared cleaning liquid L is introduced into the cleaning nozzle 1 through the cleaning liquid introduction/recovery unit 30 by operating the liquid feed pump 35 as described above.

[0050] Next, an example of the operation (sequence) of the cleaning apparatus arranged as described above will be described using FIGS. 7 to 10.

[0051] The substrate W is moved by a not shown moving unit in the moving direction A shown in FIGS. 2 to 10 at a flow velocity of 0.5 to 20 cm/sec. Then, first, the liquid feed pump 35 is operated at the time the left end of the substrate W arrives below the cleaning liquid feed member 12 the lower end surface of which is composed of the introduction opening surface 8a as shown in FIG. 7. Then, the cleaning liquid L is fed from the cleaning liquid feed member 12 onto the substrate W. At this time, the ultrasonic oscillator 10 is not yet put into operation.

[0052] When the substrate W is further moved, while the cleaning liquid L flows below the ultrasonic oscillator 10 as shown in FIG. 8, the ultrasonic oscillator 10 is not yet operated even at this time.

[0053] Further, when the substrate W is further moved and arrives below the cleaning liquid recovery member 13 the lower end surface of which is composed of the recovery opening surface 9a as shown in FIG. 9, the suction pump 38 is operated so that the cleaning liquid L, which has been fed onto the substrate W from the cleaning liquid feed member 12, is recovered from the cleaning liquid recovery member 13. At this step, since the cleaning liquid L steadily flows on the substrate W, the substrate W is cleaned with ultrasonic oscillation by operating the ultrasonic oscillator 10 simultaneously with the flow of the cleaning liquid L.

[0054] At this time, the regulator valves 37 and 39 are regulated so that the steady flow rate of the cleaning liquid L, which flows from the introduction opening surface 8a to the recovery opening surface 9a through the surface to be treated of the substrate W, is set to 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface 8a.

[0055] Finally, when the right end of the substrate W has passed below the cleaning liquid feed member 12 as shown in FIG. 10, the operation of the liquid feed pump 35 is stopped so as to stop the feed of the cleaning liquid L as well as the operation of the ultrasonic oscillator 10 is stopped. Then, finally, the cleaning liquid L remaining on the substrate W is recovered through the cleaning liquid recovery member 13. By the method described above, the movement of the substrate W from the right to the left on FIGS. 7 to 10 with respect to the cleaning nozzle 1 permits the entire region of the upper surface of the substrate W to be cleaned with ultrasonic oscillation.

[0056] In the cleaning apparatus of this embodiment, the flow rate of the treatment liquid, which flows from the introduction opening surface to the recovery opening surface through the surface to be treated of the sub-

strate W is controlled to 0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface, whereby the cleaning liquid is sufficiently distributed to the entire surface to be treated of the substrate W and flows stably as well as approximately the entire quantity of the cleaning liquid can be recovered.

[0057] Further, since the length L_N of the long side of the introduction opening surface 8a is equal to or somewhat larger than the width L_w of the substrate W, the entire region of the surface to be treated of the substrate W can be cleaned by moving the substrate W only once in one direction with respect to the cleaning nozzle 1.

[0058] Further, since the moving speed of the substrate W moved by the moving unit is set to 0.5 to 20 cm/sec in this embodiment, any problem of the adhesion of bubbles and the breakage of a treatment liquid layer does not arise so that the entire surface to be treated can be sufficiently treated in a short time.

[0059] Further, since the distance between the introduction opening surface 8a and recovery opening surface 9a of the cleaning nozzle 1 and the surface to be treated of the substrate W is set to 0.5 to 6 mm, the flow rate of 0.02 to 0.3 L/min can be easily secured as well as the flow of the treatment liquid can be made stable. Further, the contact of the nozzle 1 with the substrate W due to the vibration of the treatment apparatus can be prevented.

[0060] Further, in this embodiment, since the lengths of the respective short sides of the introduction opening surface 8a and the recovery opening surface 9a of the cleaning nozzle 1 are set to 0.01 to 2 cm, respectively, the flow rate of the cleaning liquid L of 0.02 to 0.3 L/min can be easily secured. In addition, it is also easy to uniformly feed the cleaning liquid L from the introduction opening surface 8a to the surface to be treated of the substrate W and to uniformly recover the cleaning liquid L on the surface to be treated of the substrate W through the recovery opening surface 9a.

[0061] Further, in this embodiment, since the ultrasonic oscillation application unit for applying ultrasonic oscillation to the treatment liquid L on the substrate W is interposed between the introduction opening surface 8a and the recovery opening surface 9a of the cleaning nozzle 1, ultrasonic oscillation can be applied to the treatment liquid L on the surface to be treated of the substrate W, whereby a cleaning efficiency can be improved.

[0062] Further, the oxidation-reduction potential and the pH of the treatment liquid L are controlled in this embodiment, the composition and the concentration of the treatment liquid L can be maintained optionally. As a result, even a small flow rate of the cleaning liquid L can secure a sufficient treatment efficiency.

[0063] Further, in the cleaning nozzle 1 used in the cleaning apparatus of this embodiment, the cleaning liquid L is fed onto the substrate W through the multiplicity of the through holes of the cleaning liquid feed member 12 composed of the porous material without directly dropping thereon from the introduction flow path 31. As a result, the cleaning liquid L is approximately uniformly fed from the entire surface of the cleaning liquid feed member 12 facing the substrate W and uniformly so that the cleaning liquid L is uniformly and promptly fed to an area having a certain degree of wideness on the substrate W at an approximately uniform flow velocity. Then, the cleaning liquid L is approximately uniformly recovered from the entire surface, which faces the substrate W, of the cleaning liquid recovery member 13 having the plurality of through holes. Almost no liquid reservoir is caused in the cleaning nozzle 1 of this embodiment by the actions of both the cleaning liquid feed member 12 and the cleaning liquid recovery member 13, whereby no particle stays on the substrate W and the cleaning efficiency can be improved.

[0064] Further, when the cleaning liquid feed member 12 and the cleaning liquid recovery member 13 are formed of the hydrophilic material, the cleaning liquid L can be easily distributed to the overall space between the cleaning liquid feed member 12 and cleaning liquid recovery member 13 and the substrate W, which permits the cleaning liquid L to be promptly fed onto the substrate W and to be promptly recovered therefrom. With this arrangement, the cleaning efficiency can be more improved.

[Second embodiment]

[0065] A second embodiment of the present invention will be described below with reference to FIGS. 11 and 12.

[0066] The overall arrangement of a cleaning apparatus of this embodiment is substantially the same as that of the cleaning apparatus according to the first embodiment shown in FIG. 1 except that a cleaning nozzle 15 is used in place of the cleaning nozzle 1.

[0067] Further, the basic arrangement of the cleaning nozzle 15 is similar to that of the cleaning nozzle 1 in the first embodiment except that a layer composed of a hydrophobic material is added to the cleaning nozzle 1. Thus, the components in FIGS. 11 and 12, which are common to those of FIGS. 3 and 4, are denoted by the same reference numerals and the detailed description thereof is omitted.

[0068] In the cleaning nozzle 15 of this embodiment, the periphery of a cleaning liquid feed member 12 and the periphery of a cleaning liquid recovery member 13 are covered with hydrophobic layers 16 composed of a hydrophobic material, respectively as shown in FIGS. 11 and 12. Teflon resin, silicone resin, polyethylene resin, etc., for example, can be used as the hydrophobic material. In this case, a introduction opening surface 8a and a recovery opening surface 9a are portions which are surrounded with the lower ends of the hydrophobic layers 16. While the entire peripheries of the cleaning liquid supply member 12 and the cleaning liquid recovery member 13 are covered with the hydrophobic layers

16 in this embodiment, the entire peripheries of them need not be necessarily covered with the hydrophobic layers 16, and it is sufficient to cover at least the ends of these members 12 and 13 on the sides thereof facing the substrate W with the hydrophobic layers 16.

[0069] The cleaning apparatus of this embodiment can achieve an operation/working effect similar to that of the first embodiment as to the uniform distribution of the cleaning liquid L. Further, since the wettability of the cleaning liquid L is reduced in the peripheries of the introduction opening surface 8a and the recovery opening surface 9a which are open to the atmosphere as an effect of the addition of the layer composed of the hydrophobic material to the cleaning nozzle 15, the cleaning liquid L is kept between the cleaning nozzle 15 and the substrate W so as to rise therebetween. As a result, the flow of the cleaning liquid L, which tends to leak to the outside of the cleaning nozzle 15 from the introduction opening surface 8a and the recovery opening surface 9a which are open to the atmosphere, can be suppressed. Therefore, controllability as to the keeping of the cleaning liquid L is greatly improved so that the cleaning liquid L can be reliably prevented from leaking to the outside of the cleaning nozzle 15.

[0070] While the above respective embodiments are arranged as the cleaning apparatus, the wet treatment apparatus of the present invention can be arranged as various types of wet treatment apparatuses used for etching, development, exfoliation, plating, and the like, in addition to the cleaning.

[0071] While the workpiece to be treated is disposed below the cleaning liquid nozzle in the above respective embodiments, the positional relationship between the nozzle and the workpiece to be treated is not particularly limited, and the workpiece to be treated may be disposed, for example, above the nozzle with the introduction opening surface and the recovery opening surface thereof facing upward.

[0072] Further, in the above respective embodiments, while the opening side end surfaces of the introduction opening and the recovery opening of an approximate cuboid are arranged as the introduction opening surface and the recovery opening surface, respectively, the specific shape of the nozzle is not particularly limited except that the respective opening surfaces are formed in the approximate rectangle. Further, the position where the treatment liquid is fed to the nozzle and the position from which it is recovered are not particularly limited, and, for example, the introduction pipes and the recovery pipes may be disposed on a side of the nozzle.

[Embodiment]

[0073] A relationship between a flow rate and a cleaning effect was examined using the apparatus of the second embodiment. Conditions employed in an experiment were as shown below.

(1) A glass substrate of 550 mm × 650 mm (thickness: 0.7 mm) the surface of which was forcibly polluted with alumina particles (particle size: 0.1 to 2.0 μm) was used as a substrate to be treated (workpiece to be treated). Specifically, alumina particles were dispersed in a minute amount of IPA (isopropyl alcohol) and thereafter dispersed in pure water and sprayed with a sprayer. The glass substrate was dried with a nitrogen gas sprayed thereto. Then, glass substrates polluted with particles of about 100,000 pieces/substrate each having a particle size of at least 0.5 μm were used as substances to be treated.

(2) Each of the introduction opening surface and the recovery opening surface was formed in a rectangular shape having a long side of 600 mm and a short side of 10 mm.

(3) The cleaning liquid feed member and the cleaning liquid recovery member were composed of a porous ceramic material the periphery of which is covered with fluorine resin acting as a hydrophobic material.

(4) The moving speed of the substrate was set to 20 mm/sec.

(5) The distance between the introduction opening surface and recovery opening surface and the substrate was set to 3 mm.

(6) Ultrasonic oscillation of 1 MHz was applied by an ultrasonic oscillator.

(7) Used as a cleaning liquid was ammonia water containing hydrogen gas dissolved therein, the ammonia water being controlled to have pH of about 10 and an oxidation-reduction potential of -580 mV so that the concentration of ammonia was set to about 40 ppm and the concentration of hydrogen gas was set to about 1.3 ppm.

(8) The flow rate of the cleaning liquid was varied in the range from 0.01 to 0.5 L/min per 1 cm in the long side direction of the introduction opening surface.

(9) An air knife was used to dry the substrate after it was cleaned.

[0074] FIG. 13 shows a result of the above experiment. As shown in FIG. 13, when the flow rate of the cleaning liquid L was 0.01 L/min, the quantity of the cleaning liquid was too small to sufficiently remove particles. Further, even the flow rate of the cleaning liquid of 0.5 mL/min could not sufficiently remove particles. It appears that this is because the cleaning liquid could not be fed in a state in which it was controlled excellently in one direction and particles deposited again on the substrates.

[0075] In contrast, particles could be sufficiently removed at the flow rate of 0.02 to 0.3 L/min. It appears that this is because the cleaning liquid could be sufficiently distributed to the surfaces of the substrates as well as could be sufficiently replaced by the steady flow

thereof.

[0076] Note that while the wet treatment for cleaning particles was executed in this embodiment, it is important that the treatment liquid be sufficiently distributed to a surface to be treated as well as be sufficiently replaced. Accordingly, the optimum flow rate of "0.02 to 0.3 L/min per 1 cm in the long side direction of the introduction opening surface" is also applicable to the case of other wet treatment apparatuses.

[0077] As described above in detail, the present invention has clarified the appropriate conditions to be applied when a liquid saving type wet treatment apparatus is put into operation. Accordingly, effective and efficient wet treatment can be realized by providing a wet treatment apparatus which can be operated under these optimum conditions.

Claims

1. A wet treatment apparatus, comprising:

   a nozzle having an approximately rectangular introduction opening surface which is open toward a workpiece to be treated and an approximately rectangular recovery opening surface which is open toward the workpiece, the introduction opening surface and the recovery opening surface being flush with each other and disposed with the long side directions thereof in parallel with each other;
   treatment liquid introduction means having an introduction flow path for introducing a treatment liquid between the introduction opening surface and the surface to be treated of the workpiece;
   treatment liquid recovery means having a suction pump and a recovery flow path for sucking and recovering the treatment liquid from between said recovery opening surface and the surface to be treated of the workpiece; and
   moving means for the nozzle or the workpiece for relatively moving said nozzle and the workpiece along the surface to be treated of the workpiece as well as in the short side directions of said introduction opening surface and said recovery opening surface,

   wherein the flow rate of the treatment liquid flowing from said introduction opening surface to said recovery opening surface through the surface to be treated of the workpiece is controlled to 0.02 to 0.3 L/min per 1 cm in the long side direction of said introduction opening surface.

2. A wet treatment apparatus according to claim 1, wherein the flow rate is controlled by regulating the sectional area of said introduction flow path and/or said recovery flow path.

3. A wet treatment apparatus according to claim 1 or 2, wherein the lengths of the long sides of said introduction opening surface and said recovery opening surface are equal to or larger than the width, which is in the direction parallel to the long sides, of the workpiece.

4. A wet treatment apparatus according to claim 1, 2 or 3, wherein a relative moving speed due to said moving means is 0.5 to 20 cm/sec.

5. A wet treatment apparatus according to any preceding claim, wherein the distance between said respective opening surfaces and the surface to be treated of the workpiece is 0.5 to 6 mm.

6. A wet treatment apparatus according to any preceding claim, wherein the short sides of said respective opening surfaces have a length of 0.01 to 2 cm.

7. A wet treatment apparatus according to any preceding claim, wherein ultrasonic oscillation application means is interposed between said introduction opening surface and said recovery opening surface to apply ultrasonic oscillation to the treatment liquid on the workpiece.

8. A wet treatment apparatus according to any preceding claim, comprising oxidation-reduction potential control means for the treatment liquid.

9. A wet treatment apparatus according to any preceding claim, comprising pH control means for the treatment liquid.

FIG. 1

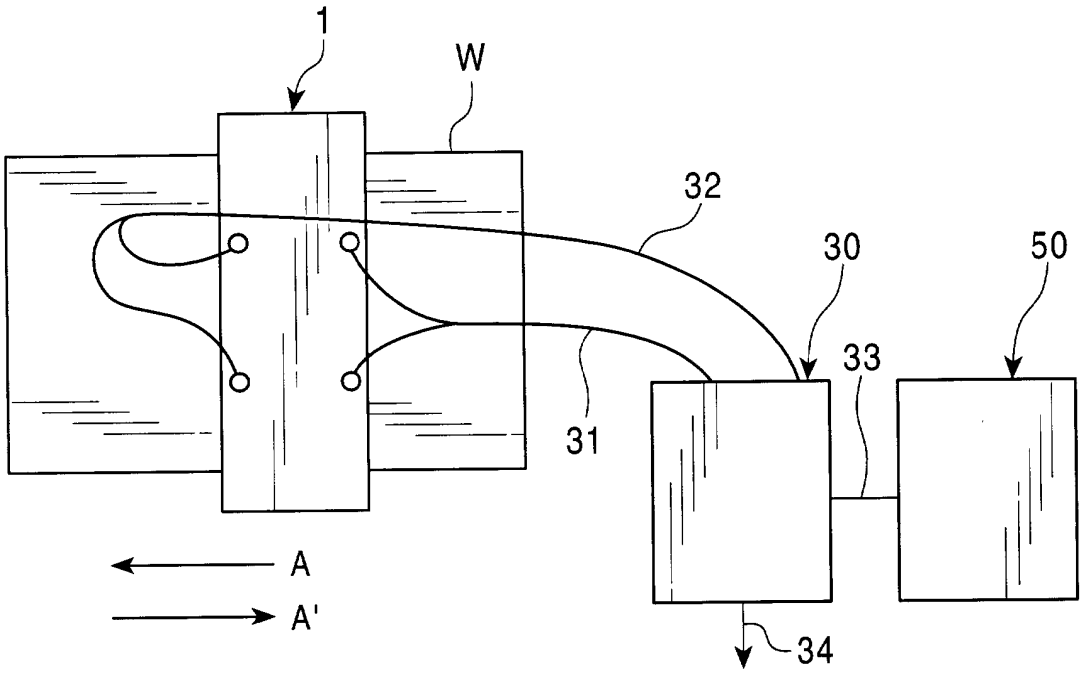


FIG. 2

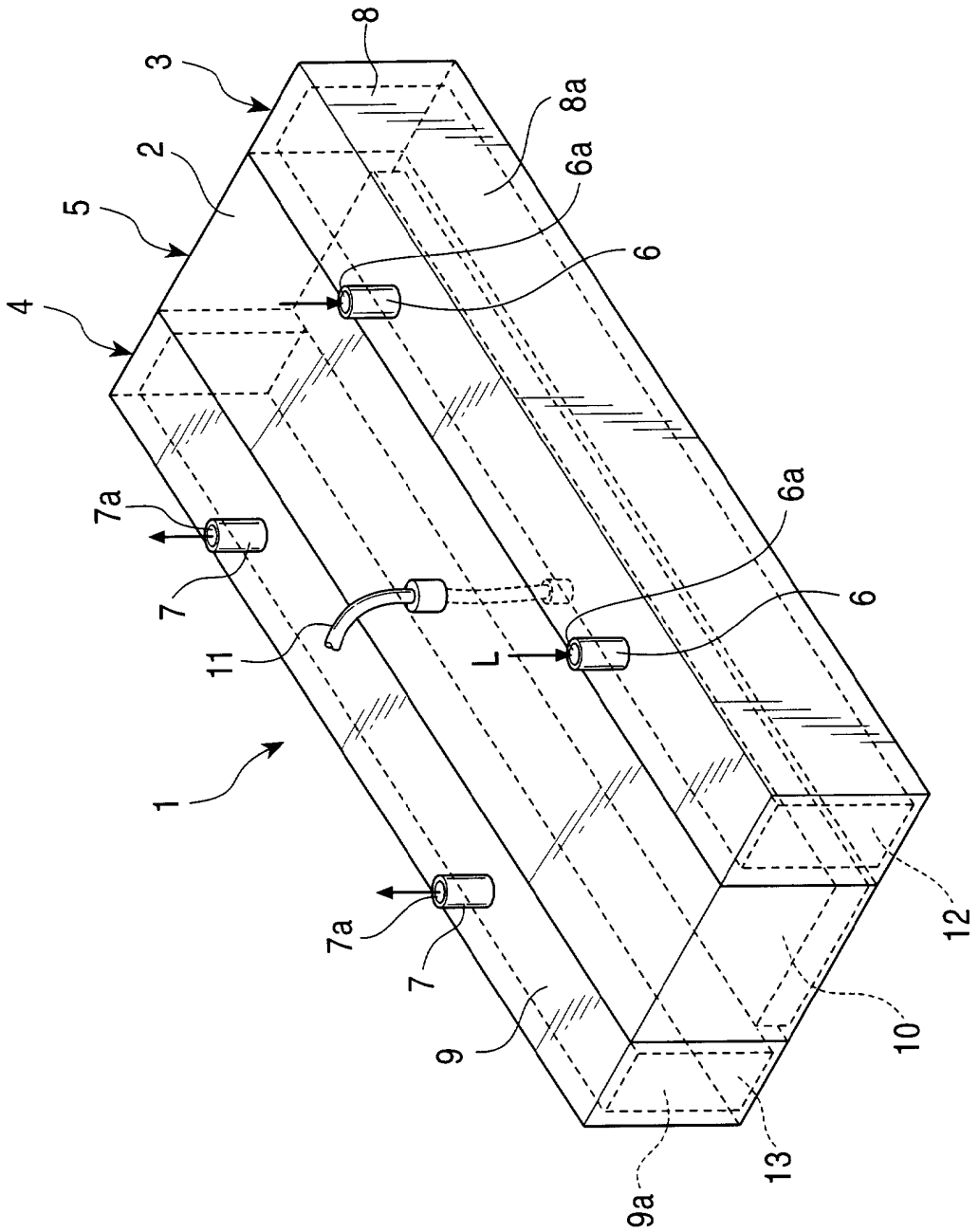


FIG. 3

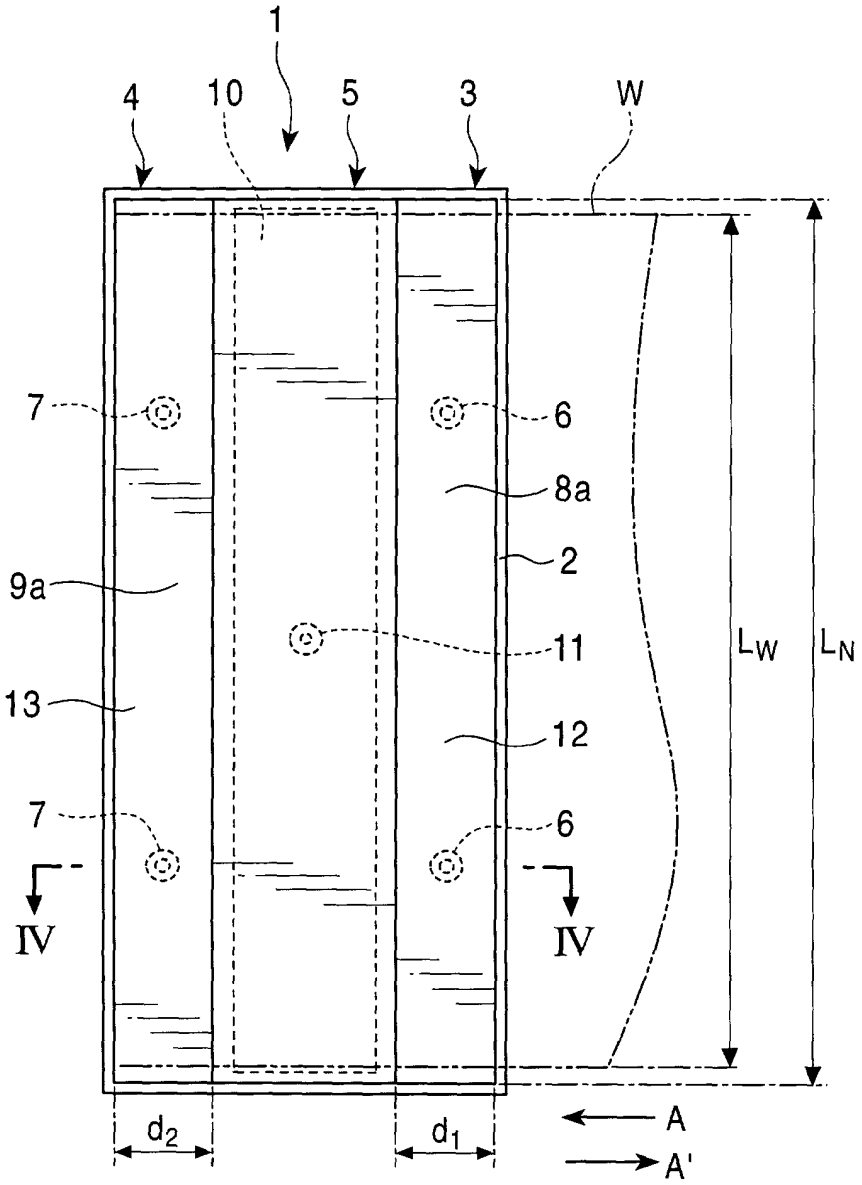
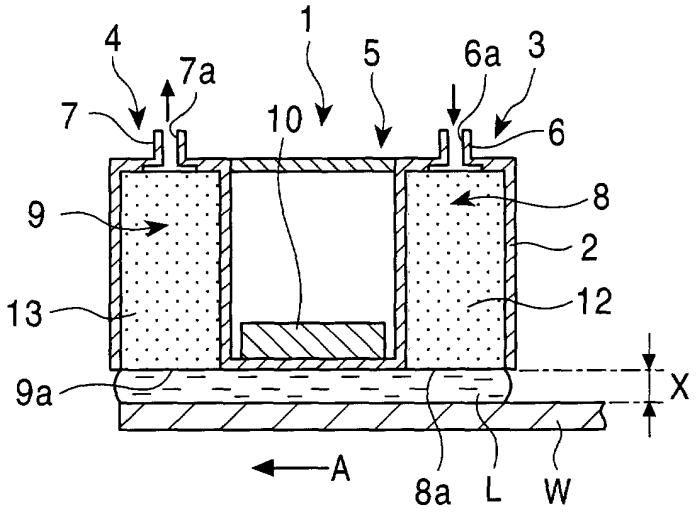


FIG. 4


1
4
7a
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2
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X
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8a
L
W

FIG. 5

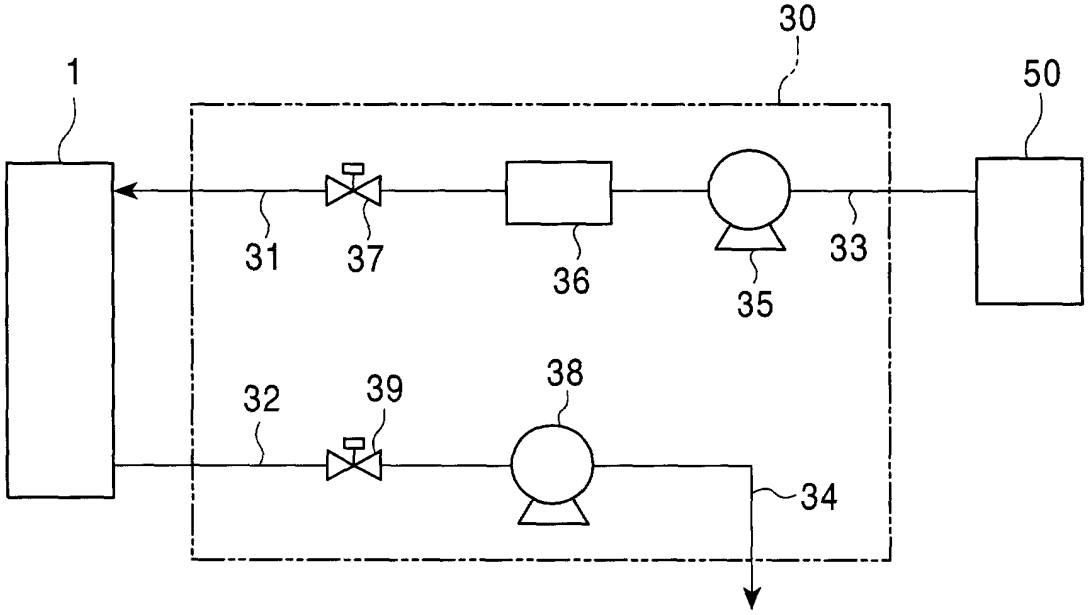
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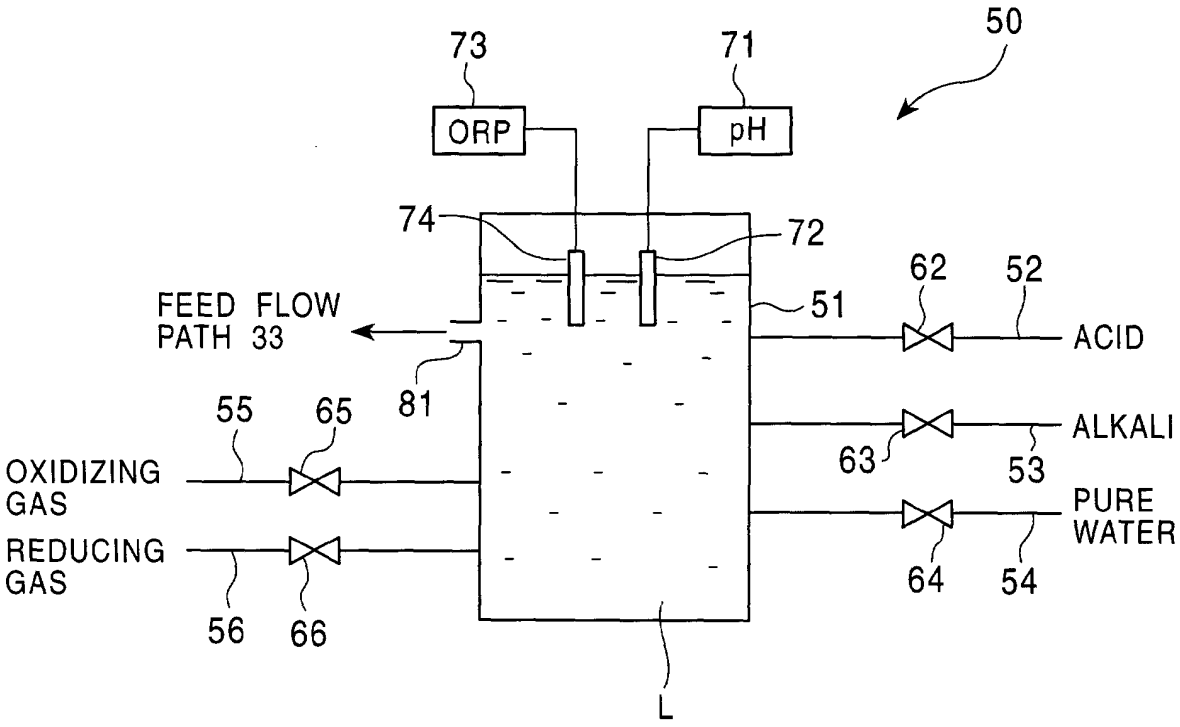
FIG. 6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FEED FLOW
PATH 33
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81
55
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OXIDIZING
GAS
PURE
WATER
REDUCING
GAS
64
54
56
66
L

FIG. 7

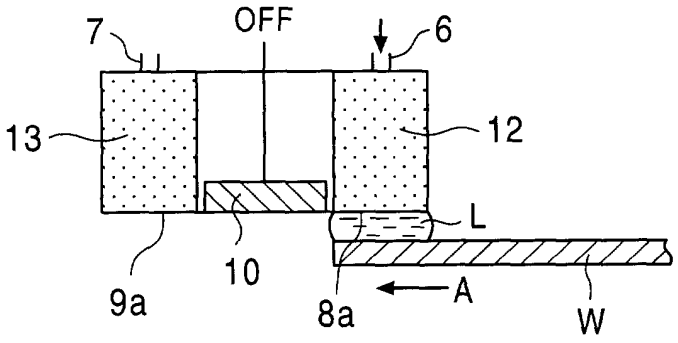


FIG. 8

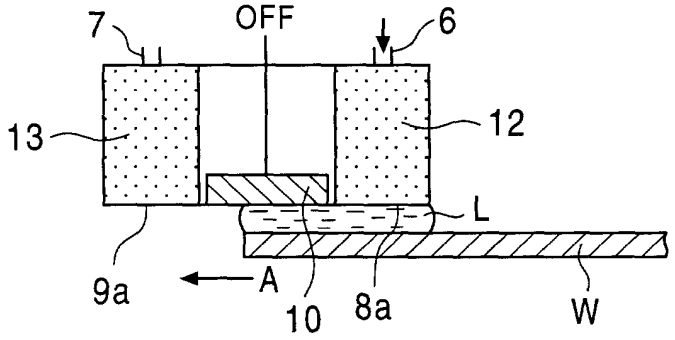


FIG. 9

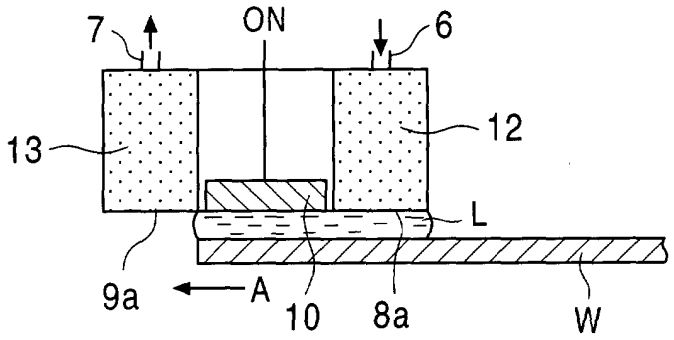


FIG. 10

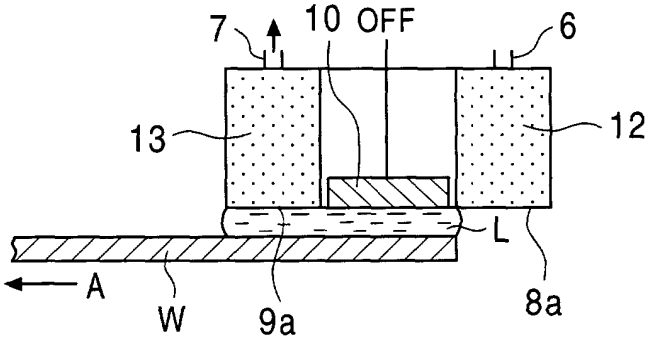


FIG. 11

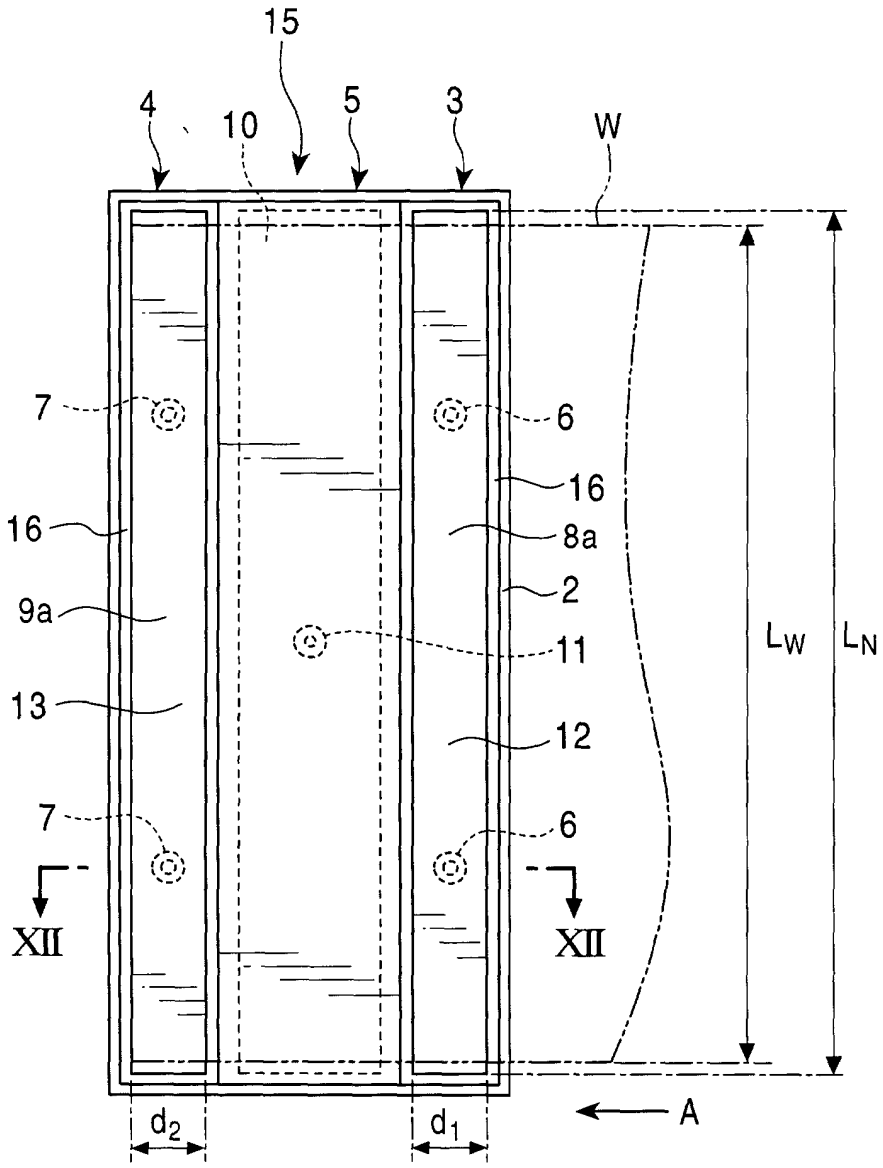


FIG. 12

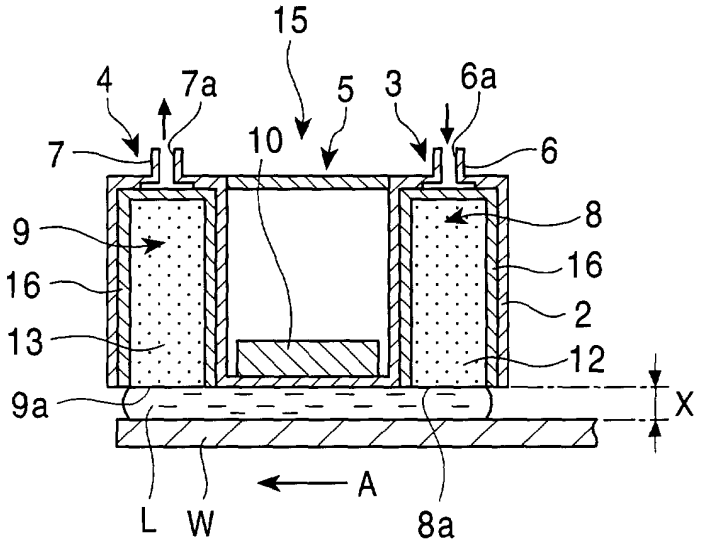
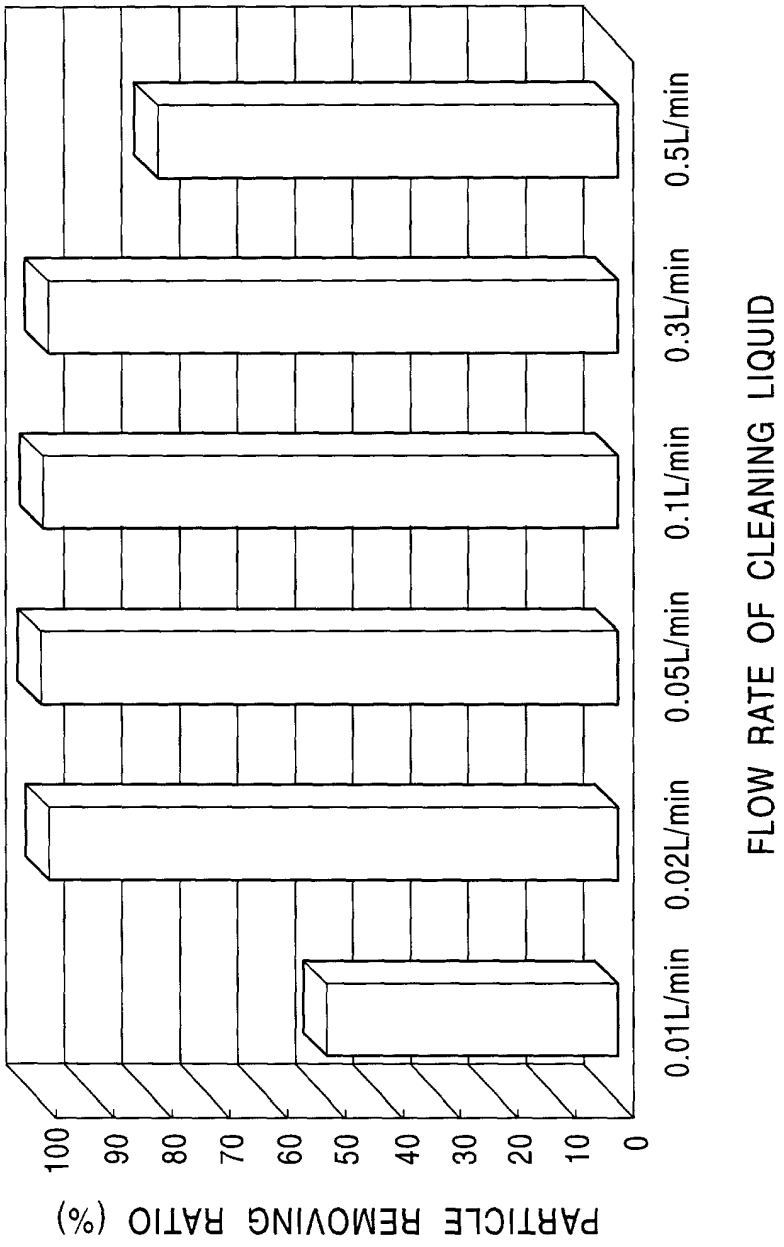


FIG. 13


PARTICLE REMOVING RATIO (%)
100
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80
70
60
50
40
30
20
10
0
0.01L/min
0.02L/min
0.05L/min
0.1L/min
0.3L/min
0.5L/min
FLOW RATE OF CLEANING LIQUID

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 5918

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B08B
H01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 November 2001	Plontz, N

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